

4.0 RADIOLOGICAL ENVIRONMENTAL PROGRAM INFORMATION

MEMP activities result in the discharge of radioactive effluents to the air and the Great Miami River. Limits on these discharges have been established by DOE and the U. S. EPA. Releases are monitored using a network of stack and water sample collection devices. In addition, MEMP maintains an extensive environmental surveillance program to evaluate the impacts from site effluents on the environment. The environmental surveillance program involves the collection and analysis of air, water, sediment, groundwater, and foodstuff samples from locations onsite and in local communities. Data generated from those programs are presented in this Chapter.

4.1 Radionuclide Releases from MEMP

2000 Data

Table 4-1 lists the quantities of radionuclides released by MEMP into the air and water during 2000. The unit used to report these quantities is the curie (Ci), a unit of radioactivity equal to 3.7×10^{10} disintegrations per second. The quantities, or activities, shown in Table 4-1 were measured at the point of release. Information on effluent monitoring systems used to estimate release levels appears in Section 4.2 of this Chapter.

Table 4-1. Radiological Effluent Data for 2000

Radionuclide	Released to	Activity, Ci	MEMP Range ^b , Ci
Tritium	Air	3.8×10^2 ^a	$3.8 \times 10^2 - 8.0 \times 10^2$
	Water	1.7	1.7 – 2.5
Plutonium-238	Air	9.4×10^{-6}	$6.9 \times 10^{-6} - 4.5 \times 10^{-5}$
	Water	1.6×10^{-4}	$1.6 \times 10^{-4} - 4.8 \times 10^{-4}$
Plutonium-239,240	Air	3.6×10^{-8}	$2.0 \times 10^{-8} - 1.0 \times 10^{-7}$
	Water	2.4×10^{-6}	$1.7 \times 10^{-6} - 3.6 \times 10^{-6}$
Radon-222	Air	3.2	$5.5 \times 10^{-1} - 3.2$
Uranium-233,234	Air	1.8×10^{-8}	$8.0 \times 10^{-9} - 9.2 \times 10^{-8}$
	Water	3.4×10^{-4}	$3.4 \times 10^{-4} - 3.9 \times 10^{-4}$
Uranium-238	Air	1.1×10^{-8}	$4.0 \times 10^{-9} - 1.1 \times 10^{-8}$

^a Tritium released to air consists of: Tritium oxide, 3.10×10^2 Ci
Elemental tritium, 7.33×10^1 Ci

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^b Minimum – Maximum (1996-2000)

4.2 Effluent Monitoring Program

Effluent monitoring focuses on releases from the site, i.e., stack and water discharges. It is MEMP's policy and philosophy that all releases of effluents from the site are ALARA, that is, As Low As Reasonably Achievable. Release trends are monitored and unexpected increases trigger internal investigations. Effluent air and water sampling locations are shown in Figure 4-1.

Applicable Standards

Guidelines for concentrations of radionuclides in air are provided in DOE Order 5400.5 (DOE, 1993a). These guides are based on recommendations in Publications 26 and 30 of the International Commission on Radiological Protection (ICRP 1977, 1979). The guides for radionuclide concentrations are referred to as Derived Concentration Guides, or DCGs. The DCG for a radionuclide is defined as the concentration of that radionuclide in air or water which will result in a 50-year committed effective dose equivalent of 100 mrem (1 mSv) if taken into the body by inhalation or ingestion during one year of exposure. DCGs are included in Appendix A. In addition, the NESHAPs radionuclide regulations (40 CFR 61, Subpart H) limit offsite doses from airborne releases from DOE sites (excluding radon) to 10 mrem effective dose equivalent (EDE) per year.

Air Emissions

Stacks through which radionuclides are released are sampled. MEMP monitors twelve point sources for radionuclides, including tritium and isotopes of plutonium and/or uranium. The average annual concentrations of radionuclide air emissions are shown in Appendix A, Table A-2. Figure 4-2 illustrates 5-year trends in releases of the radionuclides of primary interest, tritium and plutonium-238.

Tritium. In operational areas where a release potential exists, room air and exhaust stacks are continuously monitored for tritium using strategically placed ionization chambers. These monitoring systems incorporate alarms and have been placed to help to locate the source if a release should occur. In most situations, an effluent removal and containment system can be relied upon to prevent or reduce the release of tritium to the atmosphere.

Plutonium and Uranium. In areas where a release potential exists, ventilation air passes through one or more HEPA filters before being discharged to the atmosphere. Fixed continuous air samplers and continuous air monitors with alarm systems are used throughout the operational areas to detect airborne plutonium and/or uranium. These monitoring systems have been designed to ensure that prompt corrective action can be taken to reduce the magnitude of releases to the atmosphere.

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Radon. Though emission levels are negligible in comparison with natural radon emanation rates, a radon-222 release rate has been included in the 2000 effluent data (Table 4-1) in the interest of completeness. Radon-222 from natural sources, and from past operations involving radium-226 is continually released to the atmosphere from SW Building via a small roof vent. The estimated dose to the public from radon, as predicted by CAP88-PC, was 0.004 mrem for 2000.

Tritium and plutonium-238 release rates to the atmosphere have remained relatively constant over the past five years and well below regulatory thresholds. Airborne emissions of plutonium-238 were elevated in 1997 because of construction activities associated with upgrades to the SM/PP stack monitoring system which were completed in December of 1997.

Water Releases

Sampling for radionuclides is not required by the NPDES permit; however flow-proportional samples collected from outfalls 601, 602, 002, and 003 (Figure 4-1) are analyzed for tritium and isotopes of plutonium, uranium, and thorium. Samples are collected daily during the work week. Three 24-hour samples are collected on Tuesdays, Wednesdays, and Thursdays. One 96-hour (weekend) sample is collected each Monday. Samples are analyzed four times a week for tritium. Two-week composite samples are analyzed for isotopes of plutonium and uranium. The two-week composite samples are also analyzed quarterly for isotopes of thorium. Average concentrations of radionuclides in effluent waters are shown in Appendix A, Table A-3. Figure 4-3 illustrates 5-year trends in releases of the radionuclides of primary interest, tritium and plutonium-238 to the Great Miami River. Radionuclide releases to water in 2000 were consistent with previous years. Radionuclide concentrations continue to be small percentages of the respective DCGs.

4.3 Environmental Occurrences

Under CERCLA and 40 CFR Part 302, reportable quantity (RQ) levels have been established for radionuclides and other designated hazardous substances. If a spill or other inadvertent release to the environment exceeds the RQ, immediate notification of the appropriate federal agencies (e.g., National Response Center, EPA, or Coast Guard) is required. No such releases occurred at MEMP during 2000.

Figure 4-1. Effluent Air and Water Sampling Locations

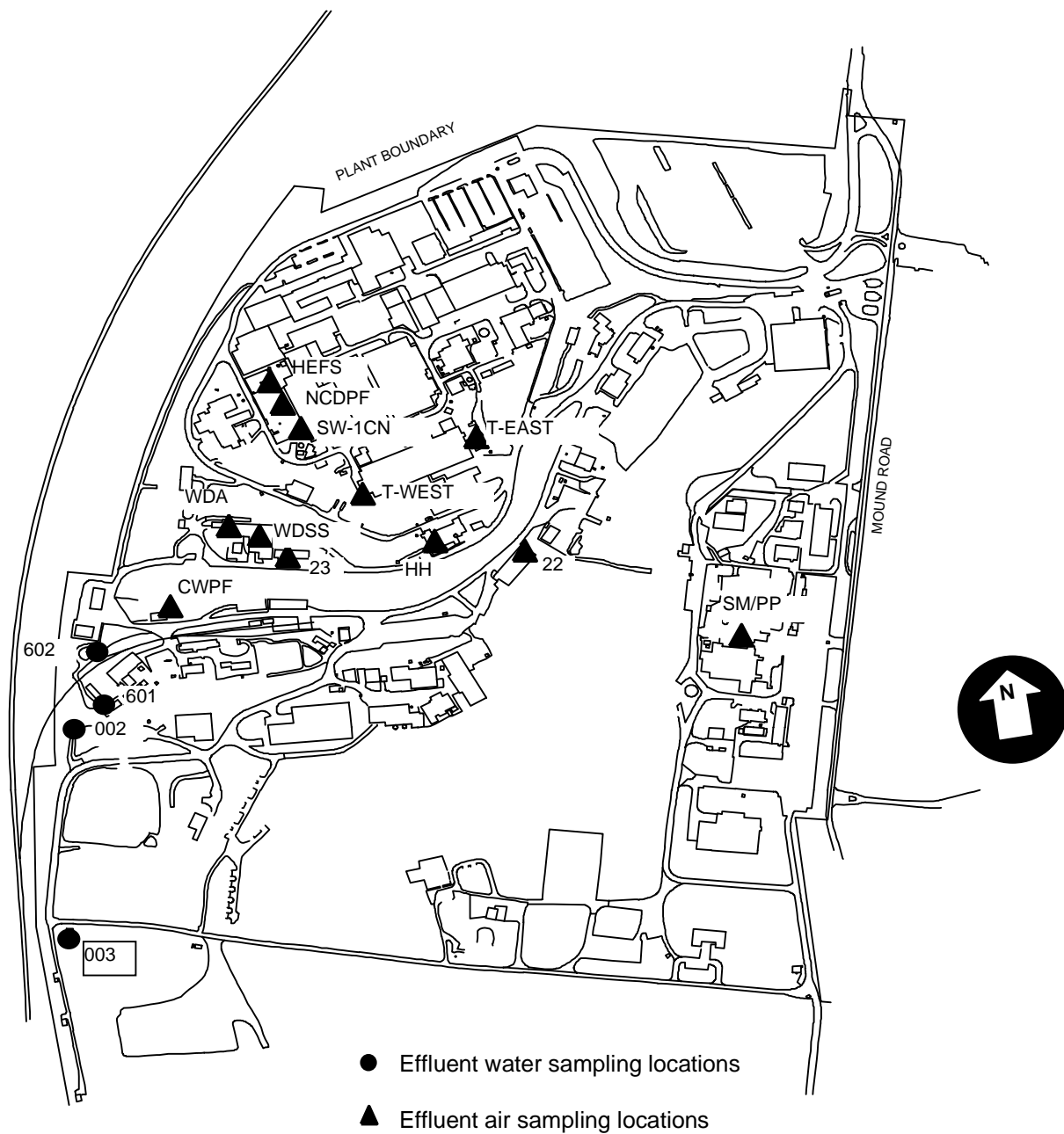


Figure 4-2. Tritium and Plutonium-238 Releases from MEMP to the Atmosphere, 1996 - 2000

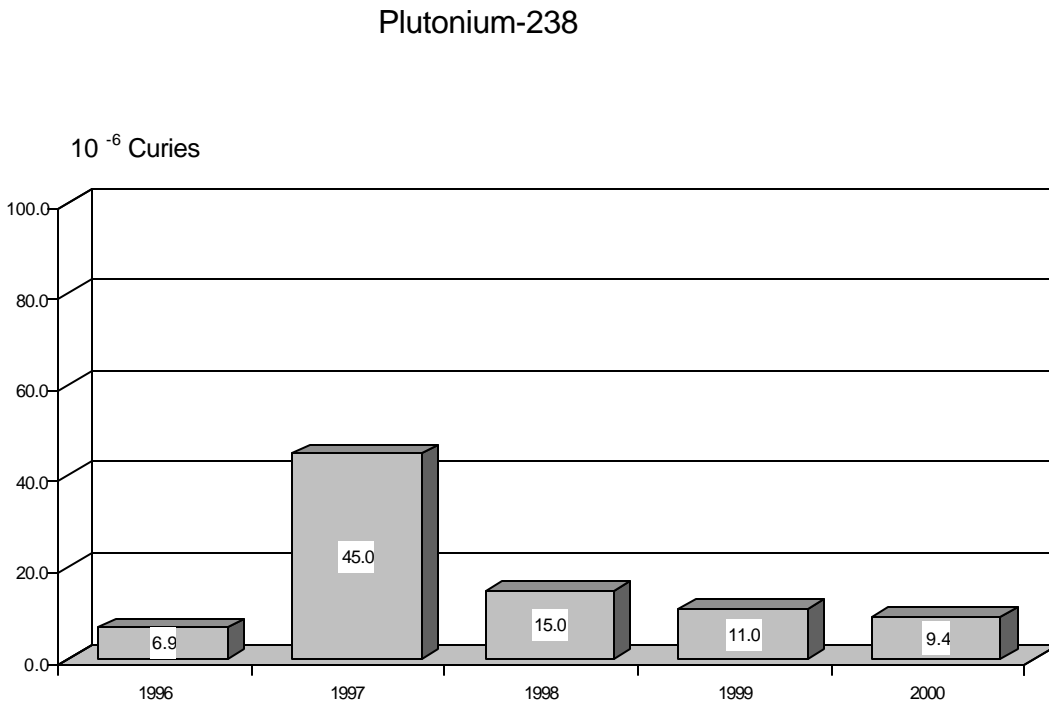
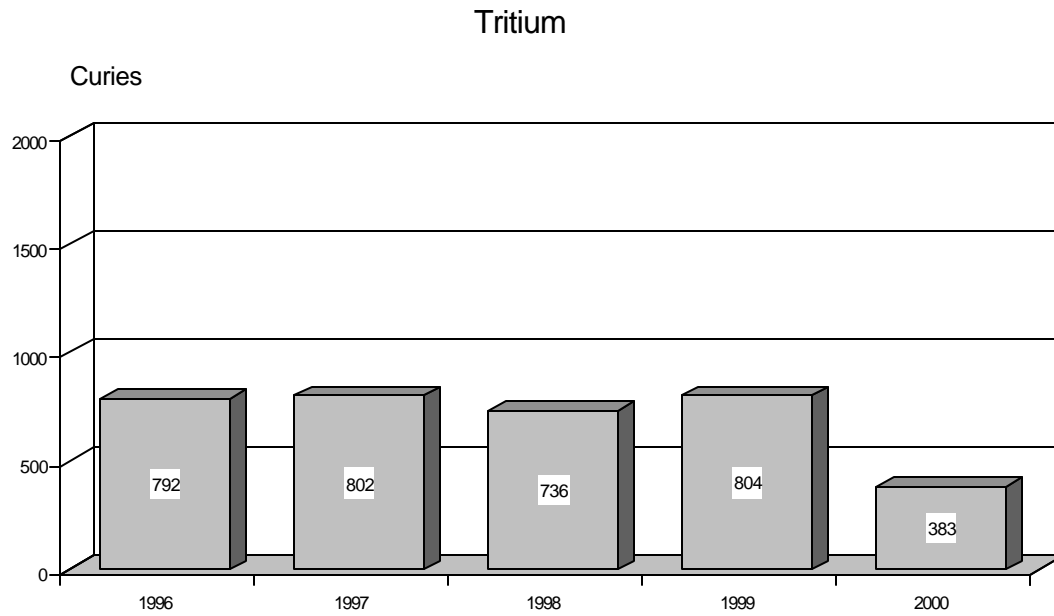
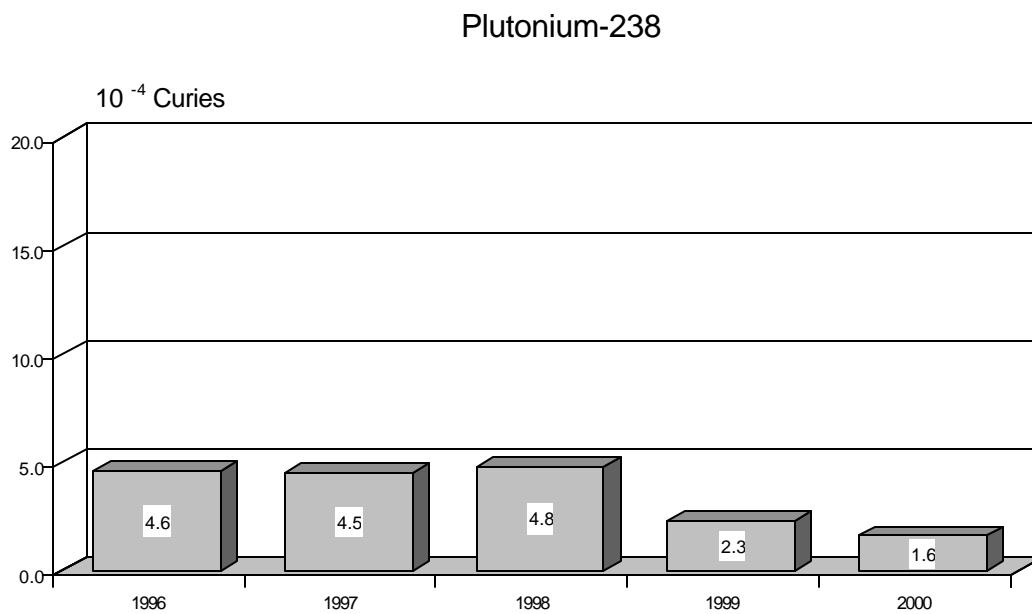
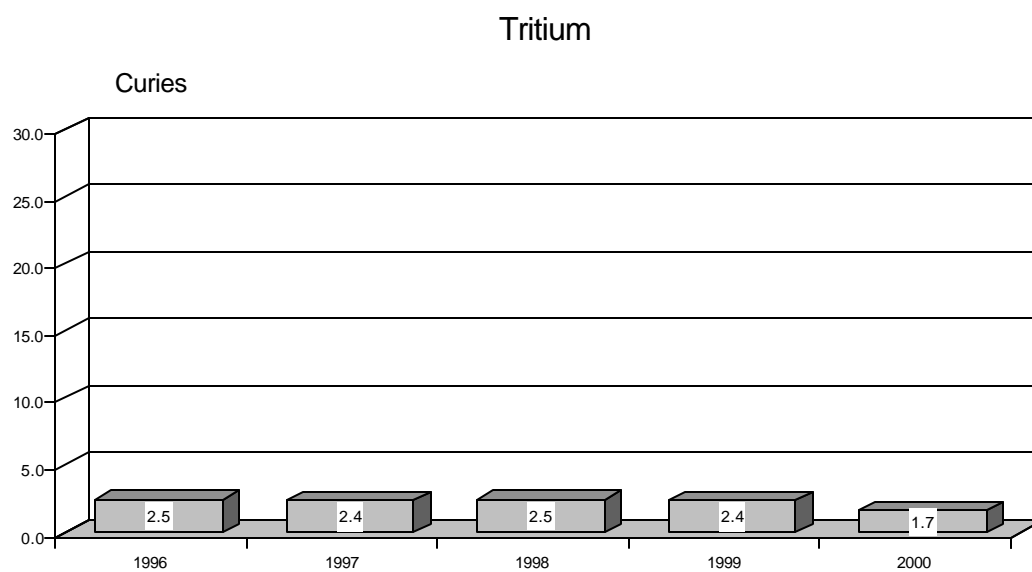


Figure 4-3. Tritium and Plutonium-238 Releases from MEMP to the Great Miami River, 1996 - 2000



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4.4 Environmental Surveillance

In the sections that follow, results of the Environmental Surveillance Program are summarized. The environmental surveillance program focuses on environmental conditions in the area surrounding the site and in local communities. Tables of monitoring results are presented in Appendix B.

Applicable Standards

Guidelines for concentrations of radionuclides in air and water are provided in DOE Order 5400.5 (DOE, 1993a). These guides are based on recommendations in Publications 26 and 30 of the International Commission on Radiological Protection (ICRP 1977, 1979). The guides for radionuclide concentrations are referred to as Derived Concentration Guides, or DCGs. The DCG for a radionuclide is defined as the concentration of that radionuclide in air or water which will result in a 50-year CEDE of 100 mrem (1 mSv) if taken into the body by inhalation or ingestion following continuous exposure for one year. DCGs are included in Appendix B.

Environmental Concentrations

In a number of the tables, results are presented as “incremental concentrations.” The designation indicates that an average background concentration, or “environmental” concentration, has been subtracted from those values. Therefore, incremental concentrations represent estimates of MEMP’s contribution to the radionuclide content of an environmental sample.



Radionuclide sample analysis

Environmental or reference locations were positioned at sites where virtually no impact from the site could be measured. The sites are in the least prevalent wind direction and/or are at substantial distances relative to the site. Environmental levels for radionuclides in different environment media are shown in Appendix B, Table B-1.

With decreasing release rates of radionuclides, it has become increasingly difficult to observe MEMP's contribution to radionuclide concentrations in the environment. For this reason, many of the tables in Appendix B report data as "below environmental levels." In those cases, it is not possible to observe an incremental concentration. In other words, the radionuclide concentration in the sample was equal to or less than the background sample.

Lower Detection Limit

All concentrations of radionuclides are determined by subtracting the instrument background and/or reagent blank from the sample count. The lower detection limit (LDL) is shown for each set of data in this Chapter. The LDL is the value at which the presence of a contaminant can be inferred at the 95% confidence level. An LDL is calculated from the instrument background or reagent blank results. Much of the radionuclide data in this report show concentrations that are below the LDL. Most of these data are incremental concentrations, i.e., the average environmental concentration has been subtracted from the result. Most of these data lie between true zero and the LDL level and are included for comparative purposes. (The measured concentration may have exceeded the LDL but, when the environmental concentration was subtracted, it fell below the LDL.) Data are reported if the concentration is below the LDL but exceeds the reagent blank or the instrument background level.

4.5 Ambient Air Sampling Program

Two types of air samples are collected at each sampling location. A particulate air sample is analyzed for plutonium-238 and plutonium-239,240. Samples from selected locations are also analyzed for thorium-228, thorium-230, and thorium-232. A second air sample, collected in a bubbler apparatus, is analyzed for tritium oxide. In 2000, 20 sampling stations were in operation: eight onsite and 12 offsite. The locations of the stations are shown in Figures 4-4 and 4-5, respectively.



Air Sampling Station

Figure 4-4. Onsite Ambient Air Sampling Locations

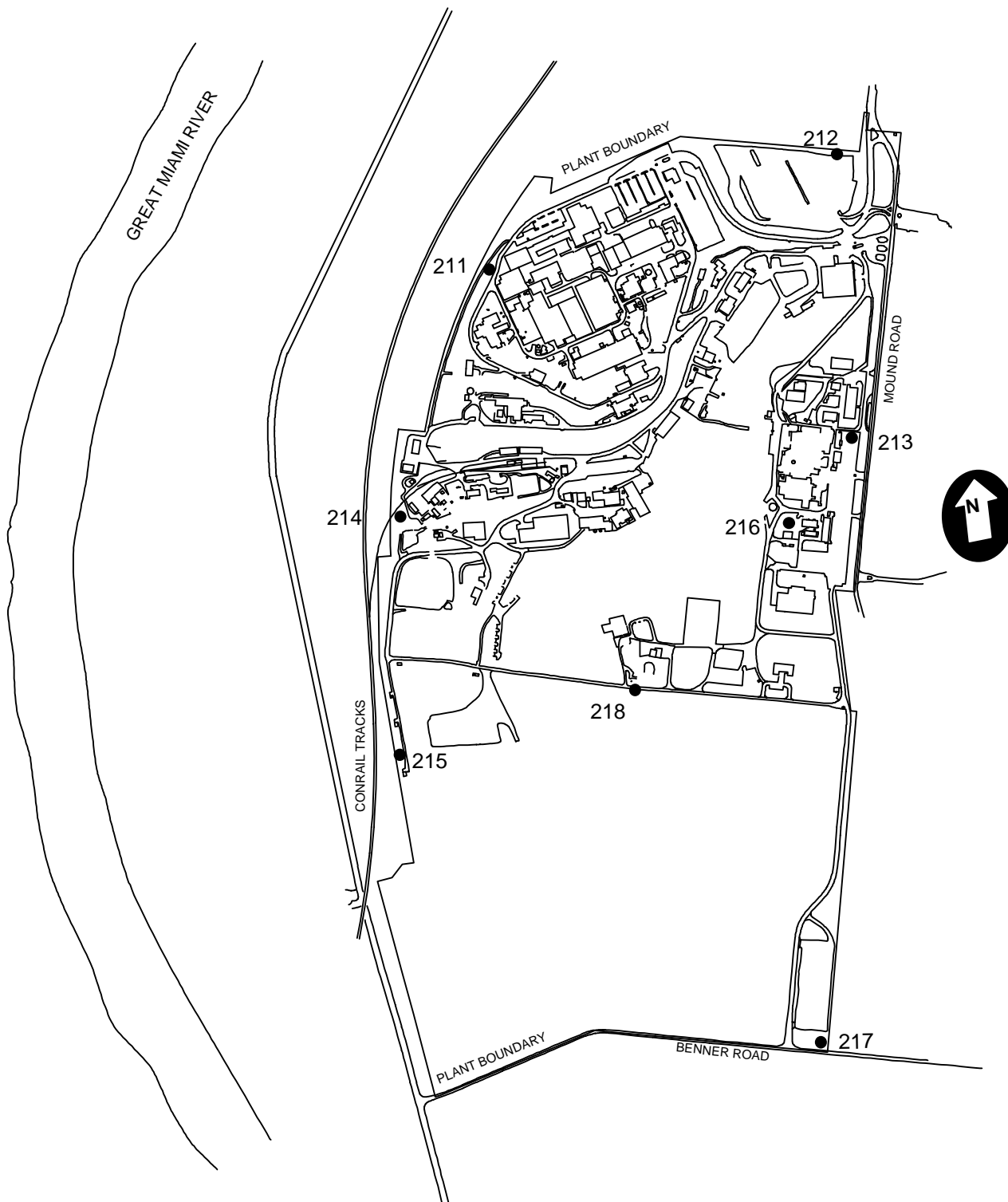
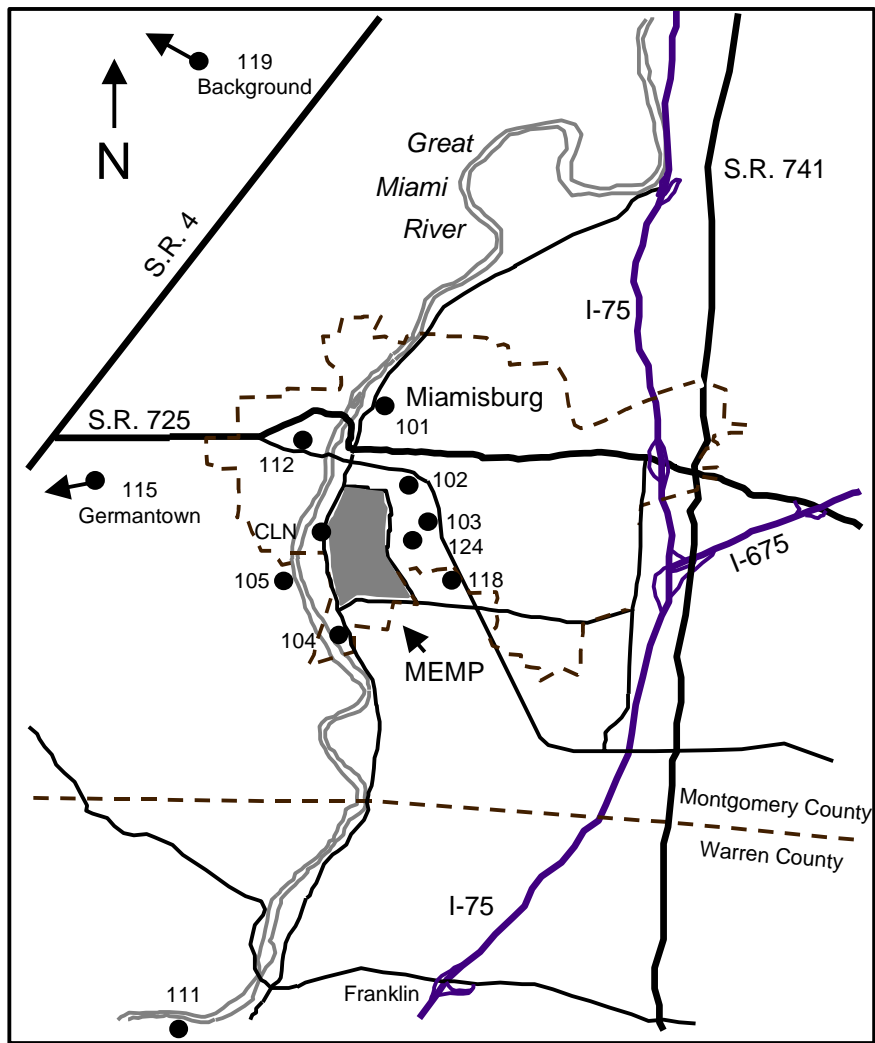


Figure 4-5. Offsite Ambient Air Sampling Locations

Tritium. Air samples for tritium analyses are collected on a continuous basis. Air is bubbled through 200 mL of ethylene glycol at a flow rate of approximately 1000 cm³/min. Ethylene glycol is used as a trapping solution because it is not subject to loss by evaporation and will not freeze when exposed to winter sampling conditions. The glycol solutions are changed weekly and represent a sample volume of approximately 10 m³ of air. An aliquot of each glycol solution is then analyzed weekly in a liquid scintillation counter.

With this technique, tritium oxide rather than elemental tritium is collected. This approach is appropriate because tritium oxide is the more radiotoxic form of tritium. The dose that would result from a given release of tritium oxide would be 25,000 times greater than the dose from the same number of curies of elemental tritium.

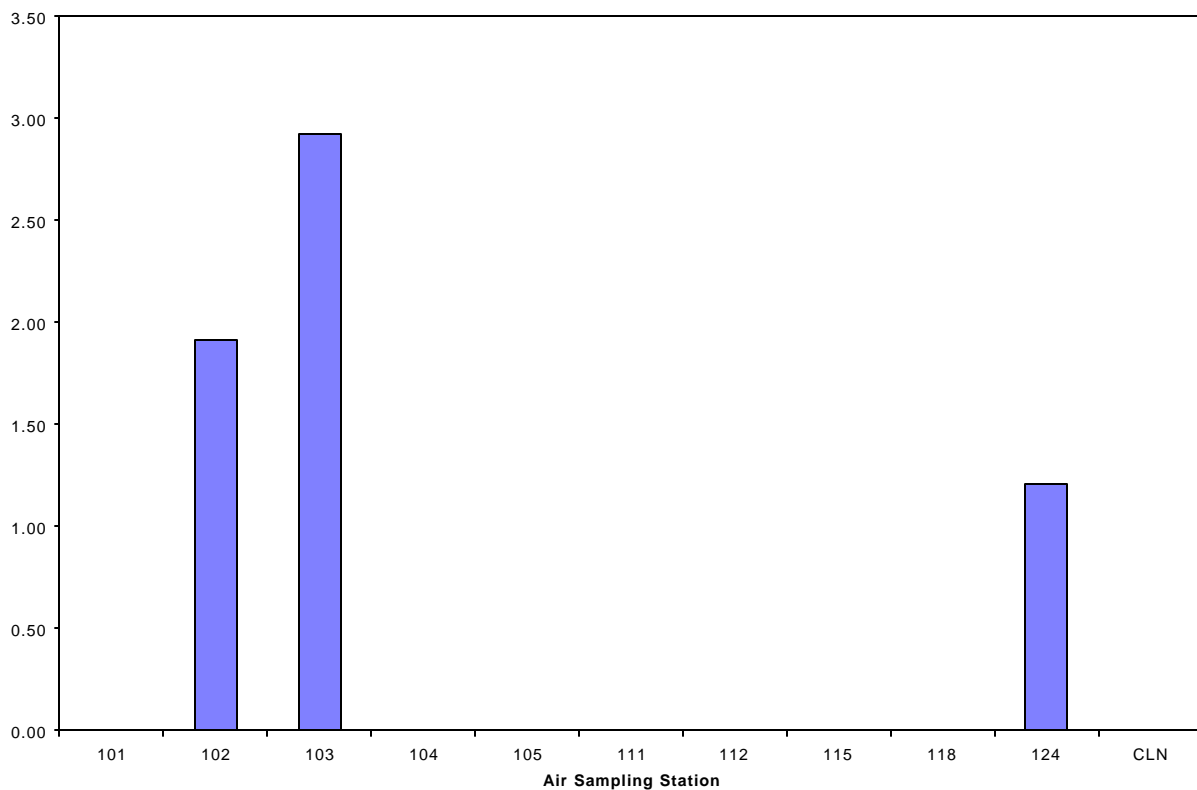


Comparisons of Predicted and Measured Tritium Concentrations

For 2000, tritium air concentrations predicted from modeling stack emissions with the EPA CAP88-PC dispersion model were compared to air concentrations observed during routine monitoring. Since essentially all of the impact from plutonium has been observed to be from resuspension of soil, and essentially all the impact from tritium has been observed to be from stack emissions, the air concentration comparison was performed for tritium (oxide) only. The predicted average concentration at offsite air sampling locations was compared with the observed incremental average concentration for 2000. Figure 4-6 shows the results of the comparison. Four concentrations were above the environmental level. One concentration was eliminated because its value was significantly lower than observed concentrations at nearby locations. There is no ratio for sampling locations 101, 105, 111, 112, 115, 118, and CLN, because the observed results were below the environmental level. This too indicates that observed results were much lower than those predicted by the model.

Figure 4-6. Predicted and Observed Concentrations of Airborne Tritium in 2000

Ratio: Predicted to Observed Concentration



Plutonium. The particulate sample for isotopic plutonium analysis is collected on a 200-mm diameter fiberglass disc by a continuously operating high-volume air sampler. The air is sampled at an average rate of $1.3 \times 10^6 \text{ cm}^3/\text{min}$ (45 ft^3/min). The disc is changed weekly and represents a sample volume of approximately 13,000 m^3 of air. Each sampler is equipped with a flow meter so location-specific flow rates can be calculated.

Plutonium analysis is performed on monthly composite samples for each onsite location and for offsite stations closest to the site. The remaining samples are composited for quarterly analysis. The analytical process for plutonium includes the following basic steps: use of an internal tracer, chemical treatment, separation of plutonium with anion exchange resin, and alpha spectroscopy.

Thorium. Particulate samples from selected air sampling locations are also analyzed for thorium. The release of thorium from ground surfaces (resuspension) is possible due to remediation activities at the site. The analytical process for thorium follows the same principles as the plutonium analysis.

Uranium. As seen in Table 4-1, MEMP includes isotopes of uranium in the release data for air. However, because the stack emissions of uranium-233,234 and uranium-238 are so low and their dose contributions are negligible, ambient air monitoring for uranium is not performed in the environment.

Results for 2000

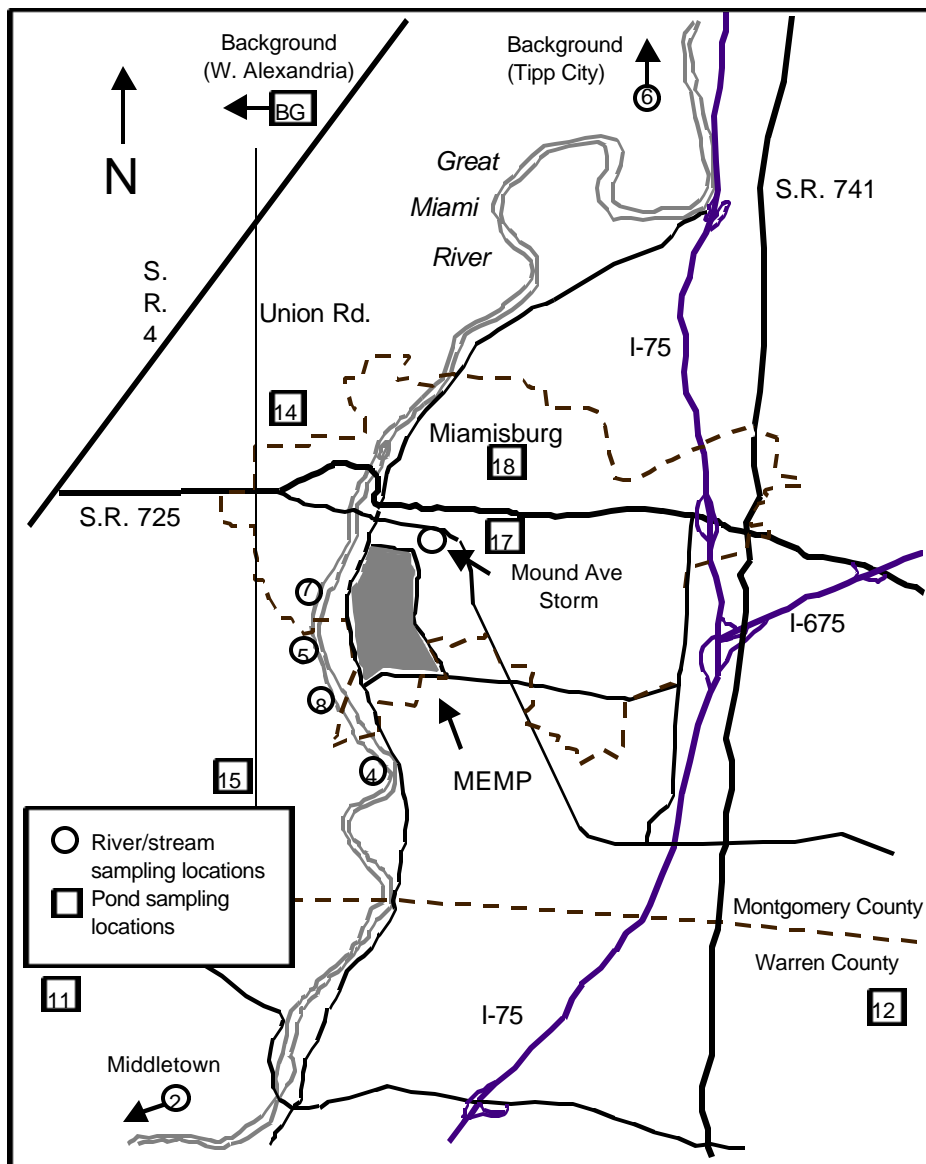
Radionuclide concentrations measured at environmental air sampling stations in 2000 are shown in Appendix B, Tables B-2 through B-5. The results are also presented in terms of the percentage DCG they represent. The tables show that air concentrations of tritium oxide averaged less than 0.0045% and plutonium averaged less than 0.045% of the DCGs established for those radionuclides. In 2000, concentrations of thorium isotopes averaged less than 0.095% of the respective DCGs.

4.6 Surface Water and Sediment Sampling Program

The Great Miami River and other regional surface waters are sampled routinely for tritium, isotopes of plutonium, and isotopes of uranium. Sediment samples are also collected from these locations and analyzed for plutonium and thorium isotopes. Sampling locations are shown in Figure 4-7.

Great Miami River and Local Stream. River sampling locations have been selected according to guidelines published by the DOE (DOE, 1991). These locations provide samples that are representative of river water at the point of entry and after considerable mixing with MEMP effluents has occurred. Tritium, plutonium-238, plutonium-239,240, uranium-233,234, and uranium-238 samples are collected and analyzed monthly. Great Miami River samples are analyzed for thorium-228, thorium-230, and thorium-232 quarterly. A local stream just northeast of the site is also sampled monthly for tritium.

Figure 4-7. Sampling Locations for the Great Miami River, Stream, Ponds, and Sediment



Local surface waters. Ponds in various compass sectors relative to MEMP are sampled annually. These samples are analyzed for tritium, plutonium-238, and plutonium-239,240.



Collection of Surface Water Samples

River and pond sediments. Many plutonium and thorium solutions, including those used at MEMP, are relatively insoluble in water. For this reason, they are more likely to be found in sediment than in surface water. Additionally, because of the relatively long half-lives of these isotopes, they may accumulate in sediments. Therefore, MEMP samples river and stream sediments on a quarterly basis and pond sediments on an annual basis. The river samples are then analyzed for plutonium-238, plutonium-239, 240, thorium-228, thorium-230, and thorium-232. The samples collected in the ponds are analyzed for plutonium-238 and plutonium-239,240.

Results for 2000

River and local stream water. Tritium, plutonium, uranium, and thorium concentrations in the Great Miami River are shown in Appendix B, Tables B-6 through B-10. Many measurements were below their respective environmental levels. Tritium concentrations were less than 0.065% of the DOE DCG. Average concentrations of plutonium and uranium isotopes were less than 4.02% of the respective DCG values. River samples were also analyzed for isotopes of thorium quarterly. Average thorium concentrations were less than 0.035% of the DOE DCGs.

Pond water. Radionuclide concentrations measured in pond water are shown in Appendix B, Tables B-11 through B-13. The pond results were less than 0.045% of the DOE DCGs.

Sediment. Plutonium and thorium results for river sediments and plutonium results for pond sediments are listed in Appendix B, Tables B-14 through B-19. Maximum and average measurements for 2000 are comparable to those observed in previous years. Since isotopes of plutonium and thorium accumulate in sediment, concentrations are affected by the movement of silt in water bodies. This accounts for the variability in plutonium concentrations at the various river and pond locations.

4.7 Foodstuffs

Various locally grown produce samples and vegetation are collected during the growing season. The objective of this aspect of the Environmental Monitoring Program is to determine whether significant concentrations of radionuclides are present in plant and animal life. In 2000, samples of root crops and leafy and non-leafy vegetables were collected from a number of regional communities.

Plutonium concentrations are determined by ashing the samples, then analyzing the sample using chemical treatment, separation with anion exchange resin, and alpha spectroscopy. Tritium concentrations are determined by distilling the water from the sample, then analyzing the distillate using liquid scintillation spectrometry.

Results for 2000

The results for foodstuff analyses are shown in Appendix B, Tables B-20 through B-22. Average incremental concentrations of tritium, plutonium-238, and plutonium-239,240 were below 55×10^{-9} , 0.025×10^{-9} , and 0.025×10^{-9} $\mu\text{Ci/g}$, respectively. These results are all lower than those of 1999.

4.8 Offsite Dose Impacts

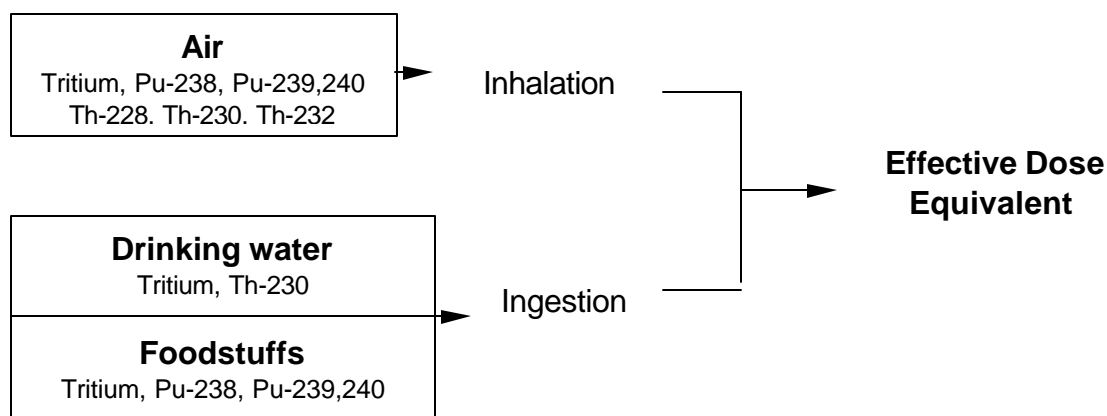
Dose Estimates Based on Measured Concentrations

MEMP used the data presented in this report to estimate maximum doses to an offsite individual. The figure-of-merit used to calculate those doses was the CEDE. CEDE calculations are required of DOE facilities. These calculations are also useful in evaluating the success of ALARA policies. It is the philosophy of DOE to ensure that all doses from radiation exposure remain ALARA.

To provide an extra degree of conservatism, dose estimates are often calculated based on maximum exposure conditions. This “maximum individual,” as defined for purposes of calculating CEDEs, is a hypothetical person who remained at the site boundary 24 hours per day throughout 2000. This individual was assumed to have:

- breathed exclusively air with radionuclide concentrations corresponding to the location of the maximum dose,
- drawn all of his drinking water from the Miamisburg water supply, and
- consumed produce exhibiting the maximum average radionuclide concentrations in samples collected from the Miamisburg/Miami Township area.

The radionuclides and the exposure pathways which contributed to the maximum individual’s CEDEs in 2000 are shown in Figure 4-8. Values for the CEDEs are shown in Table 4-2. More detailed information on the CEDE calculations, including the concentration values used, is presented in Appendix E.

Figure 4-8. Exposure Pathways for Dose Calculations Based on Measured Data for 2000

Dose Estimates for NESHAPs Compliance

NESHAPs radionuclide regulations limit offsite doses from airborne releases from DOE sites (excluding radon) to 10 mrem EDE per year. As specified by the EPA, the preferred technique for demonstrating compliance with this dose standard is a modeled approach. A comparison between measured and modeled doses can be found on page 4-11.

Maximum individual. MEMP uses the EPA computer code CAP88-PC to evaluate doses for NESHAPs compliance. The 2000 input data for the CAP88-PC calculations are listed in Appendix E. Based on the CAP88-PC output, the maximum EDE from all airborne releases was 0.03 mrem. This estimate represents 0.3% of the dose standard.

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Table 4-2. Maximum Committed Effective Dose Equivalents to a Hypothetical Individual in 2000

Radionuclide	Pathway	mrem	mSv
Tritium	Air	0.003	0.00003
	Drinking water	0.007	0.00007
	Foodstuffs	0.0007	0.000007
	Total	0.011	0.00011
Plutonium-238	Air	0.026	0.00026
	Drinking water	ND	ND
	Foodstuffs	ND	ND
	Total	0.026	0.00026
Plutonium-239,240	Air	ND	ND
	Drinking water	ND	ND
	Foodstuffs	0.007	0.00007
	Total	0.007	0.00007
Thorium-228	Air	0.019	0.00019
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.019	0.00019
Thorium-230	Air	0.024	0.00024
	Drinking water	0.001	0.00001
	Foodstuffs	NA	NA
	Total	0.025	0.00025
Thorium-232	Air	0.089	0.00089
	Drinking water	ND	ND
	Foodstuffs	NA	NA
	Total	0.089	0.00089
Total		0.177	0.00177

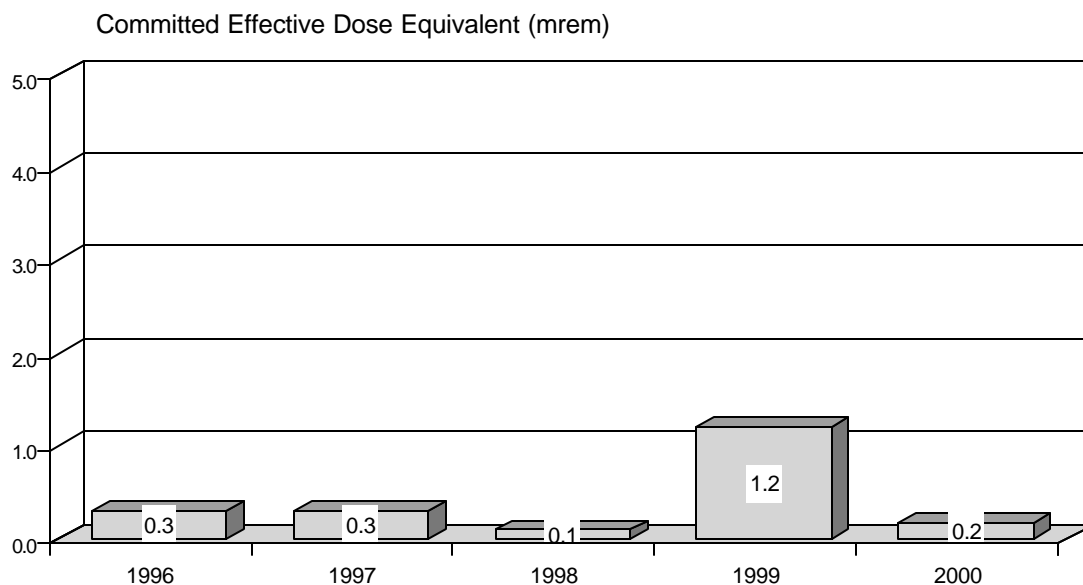
ND indicates that concentrations were not detectable above the environmental level or reagent blanks.

NA = not applicable (not measured).

Five-Year Trend in Committed Effective Dose Equivalents to a Hypothetical Individual

Figure 4-9 presents a plot showing the 5-year trend in CEDE to a hypothetical individual. The dose from MEMP activities in 2000 was a small fraction of the 100 mrem DOE dose limit for members of the public.

Figure 4-9. Committed Effective Dose Equivalents to a Hypothetical Individual, 1996 - 2000



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Population doses. CAP88-PC also has the capability of estimating regional population doses from airborne releases. The population, approximately 3,126,615 persons, within a radius of 80 km (50 mi) of MEMP received an estimated 1.3 person-rem from site activities in 2000. CAP88-PC arrived at that value by calculating doses at specific distances and in specific compass sectors relative to MEMP. The computer code then multiplied the average dose in a given area by the number of people living there. For example, an average dose of 0.001 rem x 10,000 persons in the area yields a 10 person-rem collective dose for that region. CAP88-PC then sums the collective doses for the 80-km radius region and reports a single value. Additional dose components from drinking water and radon emissions are added to obtain this result.

MEMP's dose contribution of 1.3 person-rem can be put in perspective by comparison with background doses. The average dose from background sources is 300 mrem (0.3 rem) per individual per year. A background collective dose can be estimated for the 80-km population by multiplying 0.3 rem x 3.127 million persons. The result, about one million person-rem, represents an estimate of the collective dose from all background sources of ionizing radiation. MEMP's contribution, 1.3 person-rem, is approximately 0.00013% of that value.

